

## Surficial Mapping in the McLennan Area (NTS 83N/NE), Alberta: A Small Window on the Glacial History of Alberta

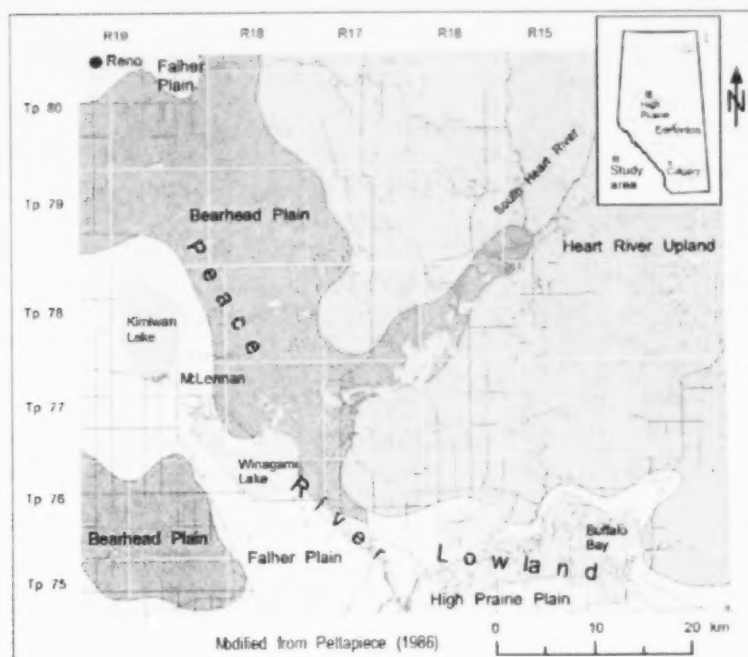
As part of a multi-year mapping initiative, the Alberta Geological Survey (AGS) undertook surficial mapping of the McLennan area (NTS 83N/NE) in the northeast quadrant of the Winagami map area. This study was primarily to map the surficial geology and determine the Quaternary history. This work was released as AGS Map 418 and Open File Report 2008-02. The study area is in north central Alberta, west of Lesser Slave Lake and about ten kilometres north of High Prairie. The town of McLennan is in the west portion of the area.

The study area encompasses two major physiographic units: the Heart River Upland in the northeast and the Peace River Lowland in the west and southwest. This lowland unit lies about 680 m above sea level (asl) and includes the Falher Plain in the west, the Bearhead Plain in the west and southwest, and the High Prairie Plain in the southeast. The physiography generally reflects the surficial geology with the Peace River Lowlands occupying a glaciolacustrine plain, while the Heart River Upland encompasses a morainal area, overlain in the southwest by thin glaciolacustrine sediment.

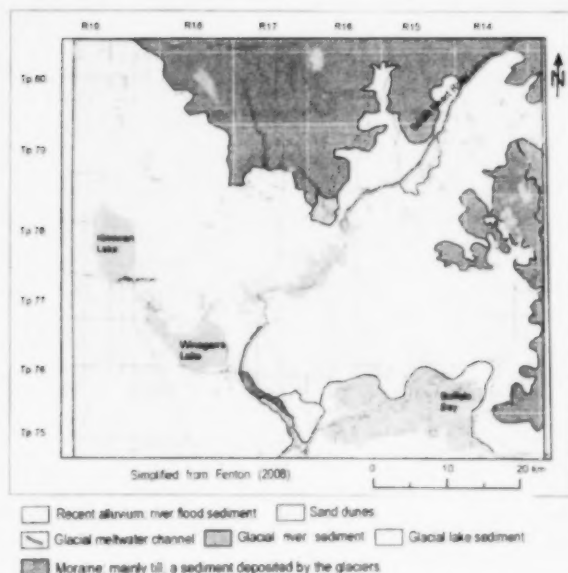
The Heart River Upland is a wooded terrain (aspen, spruce and pine) with abundant wetlands. There is extensive energy development and significant aspen

and conifer harvesting with only minor agriculture. This upland includes a broad area of moraine in the north central part. Hummocky to flat glaciolacustrine sediment covers the remainder of the upland. The Peace River Lowland is an open, low-relief to locally hummocky terrain with primarily cultivated land. Glaciolacustrine sediment, primarily clay and silt, covers this area.

The area provided valuable data for understanding the geological history of the region. During the Late Wisconsin, the last major glaciation, the Laurentide Ice Sheet flowed west and southwest, up the



Physiography of the study area.



Simplified surficial geology map.



View southward of the south Heart River meltwater channel. Hummocky glacial lake (glaciolacustrine) sediment to the west (right) of the channel and low hummocky glaciofluvial sediment to the east (left).

regional slope, overriding the entire McLennan area, and coalesced with glaciers flowing out of the Rocky Mountains near the British Columbia border. This Laurentide advance deposited the moraine that is exposed in the Heart River Upland and buried by the glaciolacustrine sediment in other parts of the area. This

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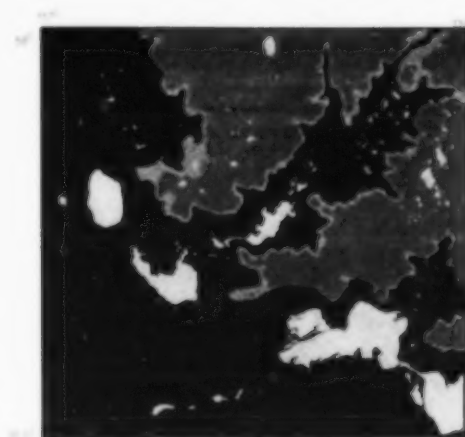


Peace River Lowland is composed mainly of open, low-relief, cultivated terrain underlain by glaciolacustrine sediment.

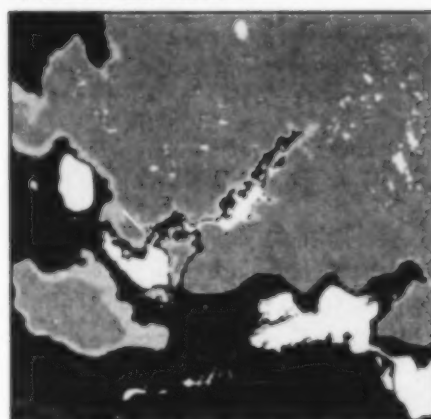
moraine is composed mainly of till and related sediment deposited by the glacier.

The upslope advance of the Laurentide Ice Sheet overrode and blocked all existing drainage channels both within and outside the study area. As this ice sheet melted and receded toward the east and north, ponded meltwater formed glacial Lake Peace and submerged the McLennan area and the adjacent region to the west and north. Subsequent drainage of glacial Lake Peace occurred in several stages as further melting of the ice margin exposed lower drainage outlets to the south and east. There is evidence for an early, likely short-lived, lake (or lakes) above about 680 m asl and three lower-level and relatively stable glacial lakes. These consist of a high-level lake formed at about 680 to 670 m asl, an intermediate level at about 640 to 630 m asl and a final, low-level lake at about 585 to 595 m asl.

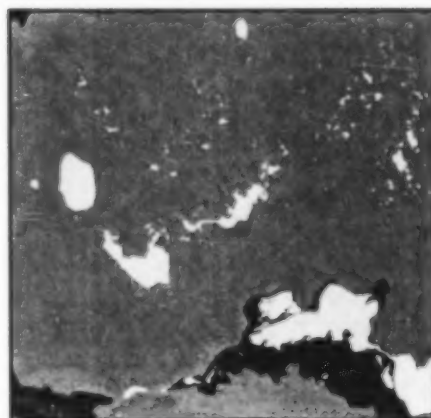
The evidence of these glacial lakes consists of both near-shore erosional and depositional features, as well as off-shore sediments deposited in deeper portions of the lake. The position of the shoreline of the high, level lake is marked, in places, by a well-developed wave-cut scarp at about 680 to 670 m asl. This deposited sediment over the Peace River Lowlands and parts of Heart River Upland (A at right). The intermediate lake level (~630 to 640 m asl) formed recognizable shorelines and shallow-water features at a number of sites. These include a wave-cut scarp southeast of Reno and surface-stone concentrations formed by wave erosion of the underlying sediment in the northwest part of the map area, and on the flanks of a emerged 'island' within glacial Lake Peace. The lowest and final lake phase



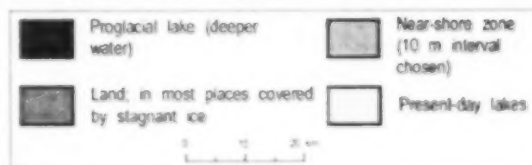
A) Lake level about 680-670 m.



B) Lake level about 640-630 m.



C) Lake level about 585-595 m.



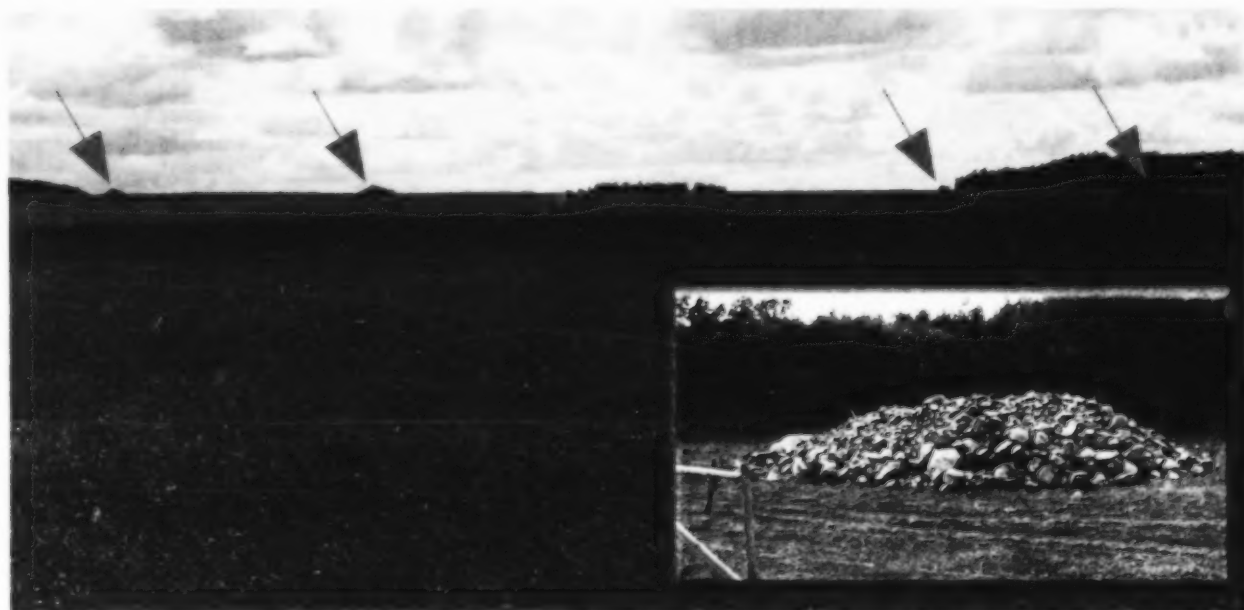
Paleogeographic maps showing the extent of the three major lake levels of glacial Lake Peace within the McLennan study area.



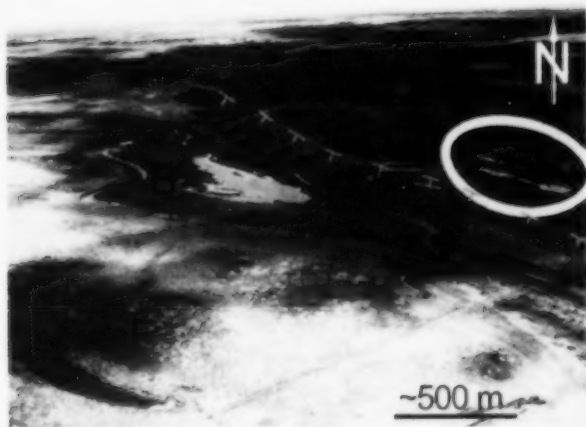
View eastward from the top of the wave-cut scarp, southeast of Reno, eroded during the 630 to 640 m asl lake level. Local relief here is about 10 m between the top of the scarp and the base (indicated by arrow).

(~595 to 585 m asl) is documented by a well-developed scarp along the lowest portion of the south flank of the Heart River Upland, in many places just above the fluvial plane. In places this scarp has been eroded into the bedrock. This final lake phase drained eastward via the channel now occupied by the Iroquois Lakes (situated just south of the study area) and into the lowland occupied by Lesser Slave Lake. Previous studies by others indicate that glacial Lake Peace drained from the study area about 11 000 to 11 500 years ago.

The sediment deposited in glacial Lake Peace also provides useful evidence about the conditions in the lake during deposition. Glaciolacustrine sediments generally form a relatively flat, low-relief plain. However, in some places, the lake sediment forms a hummocky topography suggesting it may have been deposited over remnants of glacial ice that subsequently melted to yield this topography. At some sample sites, the close proximity of the ice margin during the formation of glacial Lake Peace is recorded by alternating layers of sand and diamicton. Diamicton is a poorly sorted mixture of stony clay to sand that flows directly off the glacier. Other sample sites document deposition in deeper water and/or farther away from the glacier front. Here, rhythmites were deposited, consisting of alternating laminae of silt and clay, that in some places were deformed by stones dropped from floating icebergs.



Wave-washed till plain south of Reno where wave erosion has concentrated stones at the surface. Farmers pick the big stones from their fields and deposit them into large piles (indicated by arrows). Inset: Close-up of one pile. Igneous and metamorphic clasts glacially transported southwestward from the Precambrian Shield predominated.



Northward view over the southeast part of study area showing the fluvial plain of the South Heart River (F), wetlands (B), the low-level (585—595 m asl) wave-cut scarp (indicated by 'T' symbols) and a rotational landslide scar with sag ponds (circled). The landslide is seated within the Mesozoic shale and mudstone.

During and subsequent to the drainage of glacial Lake Peace, significant volumes of meltwater from the retreating Laurentide Ice Sheet drained through a small number of meltwater channels that cross the Heart River Upland. The largest is a southwest-trending channel occupied by the South Heart River. Another channel system trends southward, eastward and finally southward in the western portion of the area ending at a major glaciofluvial delta on the north side of the South Heart channel. In places, glaciofluvial sand has been formed into sand dunes modified by the wind.

Following the final drainage of glacial Lake Peace from the region, much of the High Prairie Plain was gradually



Mesozoic bedrock exposed along the wave-cut scarp, west of Buffalo Bay, formed during the 585 to 595 m asl lake level. This scarp is just below the glaciolacustrine rhythmites deposited at higher elevations (below right).

draped by alluvial sediment transported into this area by the South Heart River and smaller streams flowing northward from the Swan Hills Upland south of the study area. The northern portion of this plain is still subject to periodic flooding and covered by extensive wetlands, primarily marshes.

Shoreline erosion along the lowest portion of the south flanks of the Heart River Upland during the lowermost phase of glacial Lake Peace contributed locally to reduced slope stability. This is likely the reason for a few of the recent landslides seen in this area. ❖



Glaciolacustrine sediment, deposited in glacial Lake Peace, forms a plain over much of the area (left). A pit dug into the plain reveals thinly laminated glaciolacustrine rhythmites (alternating coarse and fine layers) with a dropstone that fell from floating ice and deformed the underlying layer (right).



## Geothermal Energy — New Opportunities for Alberta (Part 2)

Part 1 of this article was in the 2008 summer issue of *Rock Chips*.

Alberta Geological Survey (AGS) is focusing on shallow, low-temperature geothermal resources. This detailed, geoscience information will greatly benefit the geoexchange industry.

However, there is geological variability in the differing drilling conditions and values of thermal conductivity and diffusivity. Geological maps show the probable types of soil, sediment and bedrock at most Alberta locations. However, the wide range of published values (most from studies outside of Alberta) that link geothermal properties to geological material type hinders translation of these maps into site-specific estimates of thermal conductivity and diffusivity.

In August 2007, the Department of Energy supported AGS through the Energy Innovation Fund to start a pilot project. This project tested whether thermal conductivity values correlate to geological material type, and if existing surficial maps can estimate thermal conductivity for areas where no public values exist.

To test using geological maps for the geoexchange industry, the Edmonton area (NTS 83H) was selected and all available information on its geology and hydrogeology (e.g., drillhole lithologs, surficial maps, Quaternary stratigraphy maps and hydrogeology maps) was compiled for a three-dimensional digital model of the shallow bedrock and Quaternary drift sediments.

The thermal properties of rocks and sediment samples from outcrops were measured (Figure 1) and then compared with the average values from core samples

in purpose-drilled boreholes (Figures 1 and 2) versus in situ measurements of thermal properties measured by standard methods in those same boreholes.

The goal of this field test was to investigate the properties of shallow geological materials (in an area of thick drift over bedrock) relative to the installation and performance of vertical geoexchange systems. The study included drilling, coring, geophysical logging of surficial and bedrock materials, and thermal testing. Results will help calibrate existing geological maps.

AGS drilled and cored two boreholes (shallow and deep) at the Hastings Lake Community Hall site (Figure 1) using the mud rotary-drilling

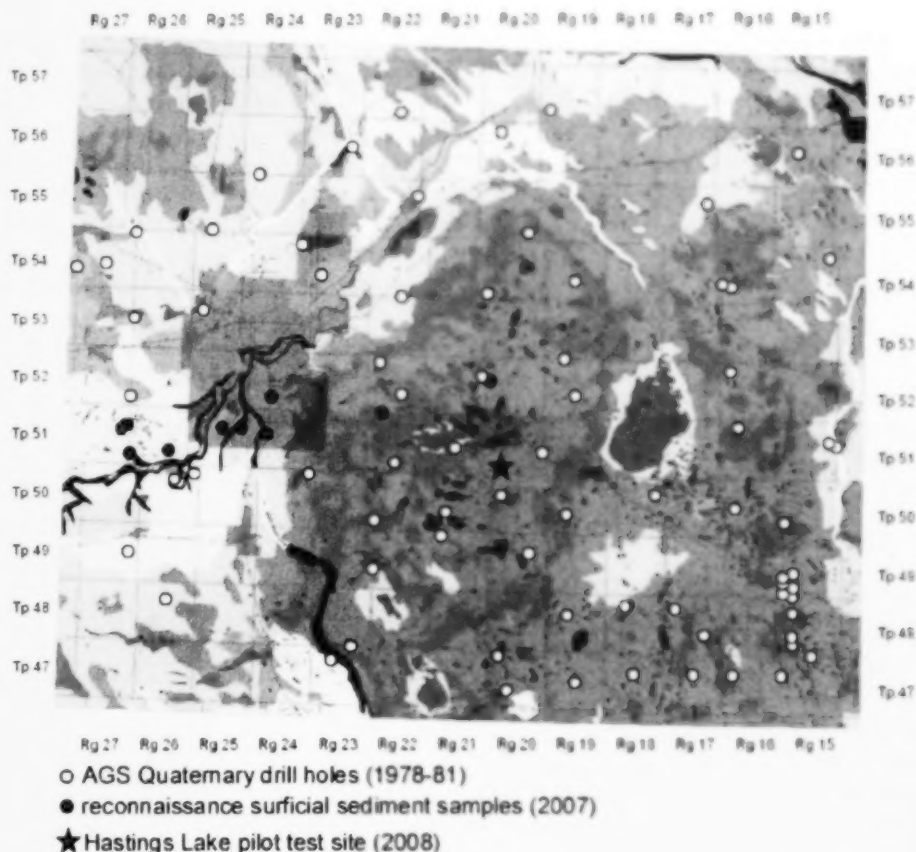


Figure 1. Surficial geology map of the Edmonton 1:250 000 map area (NTS 83H) showing existing drillhole locations and 2007 reconnaissance sample sites and Hastings Lake pilot test site.



Figure 2. Drilling and cored material (coal and siltstone) at the pilot test site near Hastings Lake east of Edmonton.

method with a Christiansen core-barrel system (Figure 2). We completed both boreholes as ground-heat exchangers by installing U-bend heat exchange tubing (U-tubes) and grouting.

Soil types encountered included drift sediments of silts, sands, clays and gravels overlying Horseshoe Canyon Formation bedrock at a depth of 42.7 m (140 ft.). Core recovery from the Quaternary drift sediments overlying the bedrock was very poor (<15%), whereas recovery from the bedrock was generally better than 80%. We drilled and completed the shallow borehole (HL08-01) to a depth of 52.1 m (171 ft.). The deep borehole (HL08-02) was drilled and completed to a depth of 122.8 m (400 ft.) in both drift sediments and bedrock.

Prior to U-tube installation with the deep borehole, downhole geophysical logging was done. We encountered zones of instability in both boreholes within the upper drift sediments, at the bedrock contact and in coal zones within the bedrock. The drift (overburden) warranted particular attention at this site because it was quite thick, and many zones within the drift sediments were loose and unstable. Successful drilling and construction of borehole heat exchangers in these conditions required greater skill and attention to detail than in other areas where the drift was thinner or more stable.

Thermal profiling and formation thermal conductivity (FTC) testing were conducted on both the shallow (HL08-01) and deep (HL08-02) borehole heat exchangers. Thermal profile results indicated a mean borehole temperature of 6.1°C at HL08-01 and 6.8°C at HL08-02. Formation thermal conductivity testing results indicated a thermal conductivity of 1.81-2.01 W/mK for HL08-01 (shallow drift deposits) and 1.59-1.74 W/mK for HL08-02 (drift and bedrock).

Initial results suggest that thermal conductivity for the drift sediments is slightly higher than the bedrock, but the undisturbed deep-ground temperature is slightly higher in the bedrock. Consequently, we believe the total required bore length to support a given heating or cooling load is similar for boreholes constructed completely in drift or those in both drift and bedrock (assuming borehole spacing is the same).

AGS is studying the material from the drillcores in detail, and we will calibrate and compare the geophysical logs with those available within the Edmonton region. The project continues this year with additional site analysis and sampling in the Edmonton region and production of thematic (geoexchange) maps. ❖

## AGS Website Gets a Makeover

Over the past year, we've asked our website users how we could improve their experience when visiting the Alberta Geological Survey's website. Thank you to all who provided their valuable suggestions. We were pleased to learn most users were very happy with the site design and functionality. Of course, there are always opportunities for improvement, and based on your feedback, we're pleased to announce the release of our new design.

The most striking change you'll notice is our navigation bar. We've updated it to a cleaner, simpler look with buttons for the areas you use most. Furthermore, we created a new *geology* button to display all of our geological topics in one convenient location.

Our home page also received a major facelift to support our three main users: people seeking geology information, GIS users and educators (see screen views below and on next pages). The new home page is now grouped into those three categories to improve your access to our content.

A key area our old site lacked was a good search tool providing relevant results. To resolve this, we switched to Google as our search engine. This should help you find what you're looking for faster and with better results.

So what's our plan for the future? Our goal is to continuously improve our website to be your best resource on Alberta's geology. In addition to more content, future changes will include improved display and search capabilities of our publications and digitizing our hard copy reports for download.

We'd love to know what you think of the new website and receive suggestions for future improvement. Please e-mail your ideas to [AGS-Webmaster@ercb.ca](mailto:AGS-Webmaster@ercb.ca) or contact us through our Facebook page (search Alberta Geological Survey). ♦

The screenshot shows the new website design for the Alberta Geological Survey. At the top, a dark banner contains the title "Alberta Geological Survey" in white. Below the banner is a navigation bar with icons and labels: Home (house icon), Geology (mountain icon), GIS Maps (A in a circle icon), Reports (book icon), Services (person icon), and Search (magnifying glass icon). To the right of the navigation bar are the logos for the Energy Resources Conservation Board (ERCB) and the Alberta Geological Survey (AGS).

On the left side, there is a vertical menu with the following links: Geology News, Newsletter & Podcasts, Co-ordinate (Map) Connectors, Alberta Diamonds, Stratigraphic Mapping, Turtle Mountain, Conferences Talks, Geology Careers, and About Us.

The main content area features three large, square tiles with images and text:

- What's in Alberta?**: Information on Alberta's geology and resources, such as gas, minerals, sand and gravel, and groundwater.
- Interactive Maps**: Interactive geological maps with downloadable GIS data.
- Teacher & Student Zone**: Activities and links for students and teachers.

Below these tiles is a section titled "What's New?" with a list of updates:

- AGS is hiring a mapping geologist. Join us.
- New shale gas page.
- Summer 2008 Rock Chips newsletter now available.

At the bottom right of the "What's New?" section is a link: [Subscribe to Updates](#).





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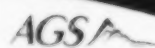


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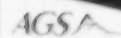


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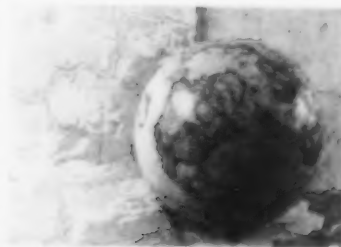
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## Interactive GIS Maps of Alberta

These interactive geological maps of Alberta will let you browse, query and download GIS data.

You can pan and zoom, click on features for more information and follow hyperlinks. Linked information includes: core photos, thin section photographs, drillhole logs, printable maps, GIS files (datasets) and related geology reports and maps.

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# Alberta Geological Survey



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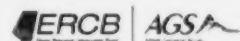
**CSUG 2008**  
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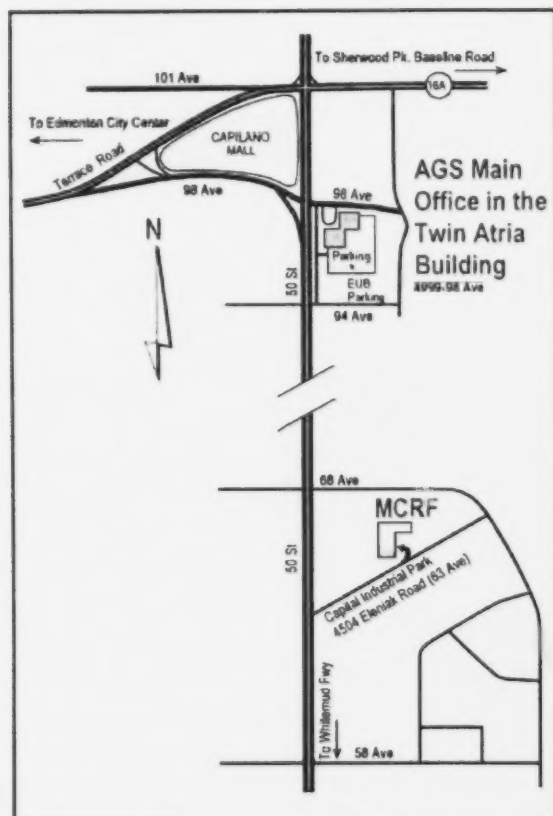
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Our Mineral Core Research Facility (MCRF) is located at

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Edmonton, Alberta

For information on the MCRF or to book a visit, contact Rob Natyshen by phone at (780) 466-1779 or by e-mail at [Rob.Natyshen@ercb.ca](mailto:Rob.Natyshen@ercb.ca)